

Description

The present invention relates to a vacuum distillation device comprising a vacuum distillation column having a column inlet, a bottom outlet and a top outlet, a furnace provided with a heat-exchange tube having a tube inlet and a tube outlet, and a connecting conduit provided with an inlet end connected to the tube outlet and an outlet end which is in fluid communication with the column inlet.

Such a vacuum distillation device is used to fractionate a hydrocarbon-containing feed. The feed is sometimes referred to as long residue. During normal operation the absolute pressure in the vacuum distillation column is maintained between 650 and 5 200 Pa. Liquid feed passing through the heat-exchange tube in the furnace is partly vaporized and the partly vaporized feed is supplied through the connecting conduit to the column inlet at a temperature of between 380 and 425 °C.

It is an object of the present invention to provide a vacuum distillation device which allows vaporization of a major part of the feed upstream the column inlet.

To this end the vacuum distillation device according to the invention is characterized in that the inner diameter of the heat-exchange tube increases along the length of the heat-exchange tube to between 2.4 and 3 times the inner diameter of the tube inlet, in that at 95% of the length of the heat-exchange tube its inner diameter is between 1.0 and 1.6 times the inner diameter of the tube inlet, and in that the inner diameter of the connecting conduit gradually increases along the length of the connecting conduit to between 2.5 and 5.4 times the inner diameter of the tube outlet.

During normal operation of the vacuum distillation device according to the invention only less than 50% by weight of the feed is vaporized in the heat-exchange tube in the furnace and more feed is vaporized in the connecting conduit, so that at the outlet end of the connecting conduit the feed comprises about 0.9 kg vapour/kg feed.

Reference is now made to German utility model publication DE-U-705 552; this publication discloses an evaporator in which a liquid is completely vaporized. To accommodate the increased amount of vapour in the evaporator tube, the diameter of the evaporator tube increases in the direction of fluid flow. In contrast to the known evaporator, the heat-exchange tube of the furnace of the present invention is so designed that substantially no vaporization occurs in the heat-exchange tube as the presence of vapour in the heat-exchange tube impairs the heat transfer from the tube to the fluid in it.

Reference is now made to USA patent specification US-A-521 974, this publication discloses an evaporator comprising a heat-exchanger with a supply conduit and a diverging outlet conduit opening into a separation chamber having a liquid outlet and a va-

pour outlet, wherein the heat-exchange tubes in the heat-exchanger have a constant diameter to suppress vaporization, wherein the inlet of the supply conduit communicates with the separation chamber, and wherein the separation chamber is furthermore provided with a feed inlet. In the known evaporator, however, the diameters of the end parts of the heat-exchange tubes do not increase. In addition, this publication is silent about the dimensions of the diverging outlet conduit.

To be able to reduce during normal operation vaporization in the heat-exchange tube and to control the velocity of the fluid in the end part of the heat-exchange tube at 95% of the length of the heat-exchange tube its inner diameter is between 1.0 and 1.6 times the inner diameter of the tube inlet of the heat-exchange tube, and at 98% of the length of the heat-exchange tube its inner diameter is between 1.7 and 2.3 times the inner diameter of the tube inlet.

Suitably at a quarter of the length of the connecting conduit its inner diameter is between 1.0 and 1.8 times the inner diameter of the tube outlet of the heat-exchange tube, at half of the length of the connecting conduit its inner diameter is between 1.3 and 2.8 times the inner diameter of the tube outlet, and at a three quarter of the length of the connecting conduit its inner diameter is between 1.7 and 4.5 times the inner diameter of the tube outlet.

The outlet end of the connecting conduit can be directly connected to the inlet of the distillation column. In an alternative embodiment, the vacuum distillation device further comprises a transfer conduit extending between the outlet end of the connecting conduit and the column inlet, which transfer conduit has an inner diameter which is between 0.7 and 5.7 times the inner diameter of the outlet end of the connecting conduit.

The present invention will now be described by way of example in more detail with reference to the accompanying drawings, wherein

Figure 1 shows schematically a partial cross-section of the vacuum distillation device according to the invention;

Figure 2 shows a top view of an alternative construction of the vacuum distillation device according to the invention; and

Figure 3 shows section III-III of Figure 2 drawn to a scale larger than the scale of Figure 2.

Reference is made to Figure 1. The vacuum distillation device comprises a vacuum distillation column 1, a furnace 2 and a connecting conduit 3.

The vacuum distillation column 1 is provided with a column inlet 6, a bottom outlet 8 having a bottom outlet conduit 9 connected thereto, and a top outlet 10. The top outlet 10 is connected by conduit 12 to a steam ejector 14 which is provided with a steam inlet conduit 16 and an outlet conduit 18. The vacuum distillation column 1 is further provided with suitable in-

ternals and draw-off means (not shown).

The furnace 2 is provided with a burner 20 having a fuel supply conduit 22 and an oxidant supply conduit 23, with a flue gas outlet conduit 25 and with a heat-exchange tube 27 having a tube inlet 28 and a tube outlet 29.

The connecting conduit 3 is provided with an inlet end 33 and an outlet end 34; the inlet end 33 is connected to the tube outlet 29 and the outlet end 34 is directly connected to the column inlet 6.

The inner diameter of the heat-exchange tube 27 increases along the length of the heat-exchange tube 27 (in the direction of fluid flow) to between 2.4 and 3 times the inner diameter of the tube inlet 28, and the inner diameter of the connecting conduit 3 gradually increases along the length of the connecting conduit (in the direction of fluid flow) to between 2.5 and 5.4 times the inner diameter of the tube outlet 29.

The inner diameter of the tube inlet 28 of the heat-exchange tube 27 is between 0.06 and 0.1 m, the length of the heat-exchange tube 27 is between 600 and 850 m, and the length of the connecting conduit 3 is between 50 and 70 m.

During normal operation the steam ejector 14 is operated to maintain a subatmospheric pressure in the vacuum distillation column 1 by supplying steam through the steam inlet conduit 16 to the steam ejector 14. Fuel and oxidant are supplied to the burner 20 of the furnace 2 to heat liquid feed supplied through tube inlet 28 and flue gas is removed from the furnace through the flue gas outlet conduit 25.

In the heat-exchange tube 27 the feed is partly vaporized, thus in the heat-exchange tube 27 there is always a liquid fraction present; this liquid fraction ensures a good heat transfer between the inner surface of the heat-exchange tube 27 and the feed flowing through the heat-exchange tube 27. An effect of the improved heat transfer is that the number of hot spots on the inner surface of wall of the heat-exchange tube 27 is reduced, so that the number of places at which liquid feed can be transformed to coke is reduced and thus the amount of fouling is reduced.

As the inner diameter of the connecting conduit 3 gradually increases, the liquid fraction of the feed is allowed to vaporize in the connecting conduit 3, so that a sufficiently large amount of the feed is vaporized.

Reference is now made to Figures 2 and 3. The vacuum distillation device comprises vacuum distillation column 1, two furnaces 2 and 2', and two connecting conduits 3 and 3'.

The vacuum distillation column 1 is provided with column inlet 6, a bottom outlet (not shown) with a bottom outlet conduit (not shown) connected thereto, and a top outlet (not shown). The top outlet is connected to a steam ejector (not shown). The vacuum distillation column 1 is further provided with suitable internals (not shown).

The furnace 2 is provided with a burner (not shown) having a fuel supply conduit (not shown) and an oxidant supply conduit (not shown), a flue gas outlet conduit (not shown) and with heat-exchange tube 27 having tube inlet 28 and tube outlet 29. The furnace 2' is provided with a burner (not shown) having a fuel supply conduit (not shown) and an oxidant supply conduit (not shown), a flue gas outlet conduit (not shown) and with heat-exchange tube 27' having tube inlet 28' and tube outlet 29'. The heat-exchange tubes 27 and 27' have the same dimensions.

The connecting conduit 3 is provided with inlet end 33 and outlet end 34; the inlet end 33 is connected to the tube outlet 29 and the outlet end 34 is in fluid communication with the column inlet 6 via transfer conduit 40. The connecting conduit 3' is provided with inlet end 33' connected to the tube outlet 29' and outlet end 34' which is in fluid communication with the column inlet 6 via transfer conduit 40. The transfer conduit 40 rests on support 42. The connecting conduits 3 and 3' have the same dimensions.

The inner diameters of the heat-exchange tubes 27 and 27' increase along the length of the heat-exchange tubes 27 and 27' to between 2.4 and 3 times the inner diameter of the tube inlets 28 and 28', and the inner diameter of the connecting conduits 3 and 3' gradually increase along the length of the connecting conduits to between 2.5 and 5.4 times the inner diameter of the tube outlets 29 and 29'.

The inner diameter of the tube inlets 28 and 28' of the heat-exchange tubes 27 and 27' is between 0.06 and 0.10 m, the length of the heat-exchange tubes 27 and 27' is between 5 200 and 6 200 m, and the length of the connecting conduits 3 and 3' is between 200 and 280 m.

The inner diameter of the transfer conduit 40 is between 2.7 and 5.7 times the inner diameter of the outlet end 34 of the connecting conduit 3, and the length of the transfer conduit 40 is between 25 and 35 m.

During normal operation a subatmospheric pressure is maintained in the vacuum distillation column 1. Fuel and oxidant are supplied to the burners of the furnaces 2 and 2' to heat liquid feed supplied through tube inlets 28 and 28' and flue gas is removed from the furnaces through the flue gas outlet conduits (not shown).

In the heat-exchange tubes 27 and 27' the feed is partly vaporized, thus in the heat-exchange tubes 27 and 27' there is always a liquid fraction present, this liquid fraction ensures a good heat transfer between the inner surface of the heat-exchange tubes 27 and 27' and the feed flowing through the heat-exchange tubes 27 and 27'.

As the inner diameters of the connecting conduits 3 and 3' gradually increase, the liquid fraction of the feed is allowed to vaporize in the connecting conduits 3 and 3'.

As observed with reference to Figure 1 the good heat transfer in the heat-exchange tubes in the furnaces reduces fouling of the inner surface of the heat-exchange tube.

Consequently more heat can be supplied per unit of time to the feed in the heat-exchange tube; this allows either to heat the feed to a higher temperature or to increase the throughput for the same temperature.

Claims

1. Vacuum distillation device comprising a vacuum distillation column (1) having a column inlet (6), a bottom outlet (8) and a top outlet (10), a furnace (2) provided with a heat-exchange tube (27) having a tube inlet (28) and a tube outlet (29), and a connecting conduit (3) provided with an inlet end (33) connected to the tube outlet (29) and an outlet end (34) which is in fluid communication with the column inlet (6), characterized in that the inner diameter of the heat-exchange tube (27) increases along the length of the heat-exchange tube (27) to between 2.4 and 3 times the inner diameter of the tube inlet (28), in that at 95% of the length of the heat-exchange tube (27) its inner diameter is between 1.0 and 1.6 times the inner diameter of the tube inlet (28), and in that the inner diameter of the connecting conduit (3) gradually increases along the length of the connecting conduit (3) to between 2.5 and 5.4 times the inner diameter of the tube outlet (28).
2. Vacuum distillation device as claimed in claim 1, wherein at 98% of the length of the heat-exchange tube (27) its inner diameter is between 1.7 and 2.3 times the inner diameter of the tube inlet (28).
3. Vacuum distillation device as claimed in claim 1 or 2, wherein at a quarter of the length of the connecting conduit (3) its inner diameter is between 1.0 and 1.8 times the inner diameter of the tube outlet (29).
4. Vacuum distillation device as claimed in anyone of the claims 1-3, wherein at half of the length of the connecting conduit (3) its inner diameter is between 1.3 and 1.8 times the inner diameter of the tube outlet (29).
5. Vacuum distillation device as claimed in anyone of the claims 1-4, wherein at a three quarter of the length of the connecting conduit (3) its inner diameter is between 1.7 and 4.5 times the inner diameter of the tube outlet (29).

6. Vacuum distillation device as claimed in anyone of the claims 1-5, further comprising a transfer conduit (40) extending between the outlet end (34) of the connecting conduit (3) and the column inlet (6), which transfer conduit (40) has an inner diameter which is between 0.7 and 5.7 times the inner diameter of the outlet end (34) of the connecting conduit (3).

Patentansprüche

1. Vorrichtung zur Vakuumdestillation, umfassend eine Vakuumdestillationssäule (1), die einen Säuleneinlaß (6), einen Bodenauslaß (8) und einen oberen Auslaß (10) hat, einen Ofen (2), der mit einem Wärmeaustauschrohr (27) versehen ist, welches einen Rohreinlaß (28) und einen Rohrauslaß (29) hat, und eine Verbindungsleitung (3), die mit einem Einlaßende (33), das mit dem Rohrauslaß (29) verbunden ist, und ein Auslaßende (34) hat, welches sich in Fluidverbindung mit dem Säuleneinlaß (6) befindet, dadurch gekennzeichnet, daß der Innendurchmesser des Wärmeaustauschrohres (27) sich entlang der Länge des Wärmeaustauschrohres (27) auf einen Wert zwischen dem 2,4-fachen und dem 3-fachen des Innendurchmessers des Rohreinlasses (28) vergrößert, daß bei 95 % der Länge des Wärmeaustauschrohres (27) sein Innendurchmesser zwischen dem 1,0-fachen und dem 1,6-fachen des Innendurchmessers des Rohreinlasses (28) liegt, und daß der Innendurchmesser der Verbindungsleitung (3) sich entlang der Länge der Verbindungsleitung (3) allmählich auf einen Wert zwischen dem 2,5-fachen und dem 5,4-fachen des Innendurchmessers des Rohrauslasses (28) vergrößert.
2. Vorrichtung zur Vakuumdestillation nach Anspruch 1, wobei bei 98% der Länge des Wärmeaustauschrohres (27) sein Durchmesser zwischen dem 1,7-fachen und dem 2,3-fachen des Innendurchmessers des Rohreinlasses (28) liegt.
3. Vorrichtung zur Vakuumdestillation nach Anspruch 1 oder 2, wobei bei einem Viertel der Länge der Verbindungsleitung (3) ihr Innendurchmesser zwischen dem 1,0-fachen und dem 1,8-fachen des Innendurchmessers des Rohrauslasses (29) liegt.
4. Vorrichtung zur Vakuumdestillation nach irgendeinem der Ansprüche 1 bis 3, wobei bei der Hälfte der Länge der Verbindungsleitung (3) ihr Innendurchmesser zwischen dem 1,3-fachen und dem 1,8-fachen des Innendurchmessers des Rohrauslasses (29) liegt.



As observed with reference to Figure 1 the good heat transfer in the heat-exchange tubes in the furnaces reduces fouling of the inner surface of the heat-exchange tube.

Consequently more heat can be supplied per unit of time to the feed in the heat-exchange tube; this allows either to heat the feed to a higher temperature or to increase the throughput for the same temperature.

Claims

1. Vacuum distillation device comprising a vacuum distillation column (1) having a column inlet (6), a bottom outlet (8) and a top outlet (10), a furnace (2) provided with a heat-exchange tube (27) having a tube inlet (28) and a tube outlet (29), and a connecting conduit (3) provided with an inlet end (33) connected to the tube outlet (29) and an outlet end (34) which is in fluid communication with the column inlet (6), characterized in that the inner diameter of the heat-exchange tube (27) increases along the length of the heat-exchange tube (27) to between 2.4 and 3 times the inner diameter of the tube inlet (28), in that at 95% of the length of the heat-exchange tube (27) its inner diameter is between 1.0 and 1.6 times the inner diameter of the tube inlet (28), and in that the inner diameter of the connecting conduit (3) gradually increases along the length of the connecting conduit (3) to between 2.5 and 5.4 times the inner diameter of the tube outlet (28).
2. Vacuum distillation device as claimed in claim 1, wherein at 98% of the length of the heat-exchange tube (27) its inner diameter is between 1.7 and 2.3 times the inner diameter of the tube inlet (28).
3. Vacuum distillation device as claimed in claim 1 or 2, wherein at a quarter of the length of the connecting conduit (3) its inner diameter is between 1.0 and 1.8 times the inner diameter of the tube outlet (29).
4. Vacuum distillation device as claimed in anyone of the claims 1-3, wherein at half of the length of the connecting conduit (3) its inner diameter is between 1.3 and 1.8 times the inner diameter of the tube outlet (29).
5. Vacuum distillation device as claimed in anyone of the claims 1-4, wherein at a three quarter of the length of the connecting conduit (3) its inner diameter is between 1.7 and 4.5 times the inner diameter of the tube outlet (29).

6. Vacuum distillation device as claimed in anyone of the claims 1-5, further comprising a transfer conduit (40) extending between the outlet end (34) of the connecting conduit (3) and the column inlet (6), which transfer conduit (40) has an inner diameter which is between 0.7 and 5.7 times the inner diameter of the outlet end (34) of the connecting conduit (3).

Patentansprüche

1. Vorrichtung zur Vakuumdestillation, umfassend eine Vakuumdestillationssäule (1), die einen Säuleneinlaß (6), einen Bodenauslaß (8) und einen oberen Auslaß (10) hat, einen Ofen (2), der mit einem Wärmeaustauschrohr (27) versehen ist, welches einen Rohreinlaß (28) und einen Rohrauslaß (29) hat, und eine Verbindungsleitung (3), die mit einem Einlaßende (33), das mit dem Rohrauslaß (29) verbunden ist, und ein Auslaßende (34) hat, welches sich in Fluidverbindung mit dem Säuleneinlaß (6) befindet, dadurch gekennzeichnet, daß der Innendurchmesser des Wärmeaustauschrohres (27) sich entlang der Länge des Wärmeaustauschrohres (27) auf einen Wert zwischen dem 2,4-fachen und dem 3-fachen des Innendurchmessers des Rohreinlasses (28) vergrößert, daß bei 95 % der Länge des Wärmeaustauschrohres (27) sein Innendurchmesser zwischen dem 1,0-fachen und dem 1,6-fachen des Innendurchmessers des Rohreinlasses (28) liegt, und daß der Innendurchmesser der Verbindungsleitung (3) sich entlang der Länge der Verbindungsleitung (3) allmählich auf einen Wert zwischen dem 2,5-fachen und dem 5,4-fachen des Innendurchmessers des Rohrauslasses (28) vergrößert.
2. Vorrichtung zur Vakuumdestillation nach Anspruch 1, wobei bei 98% der Länge des Wärmeaustauschrohres (27) sein Durchmesser zwischen dem 1,7-fachen und dem 2,3-fachen des Innendurchmessers des Rohreinlasses (28) liegt.
3. Vorrichtung zur Vakuumdestillation nach Anspruch 1 oder 2, wobei bei einem Viertel der Länge der Verbindungsleitung (3) ihr Innendurchmesser zwischen dem 1,0-fachen und dem 1,8-fachen des Innendurchmessers des Rohrauslasses (29) liegt.
4. Vorrichtung zur Vakuumdestillation nach irgendeinem der Ansprüche 1 bis 3, wobei bei der Hälfte der Länge der Verbindungsleitung (3) ihr Innendurchmesser zwischen dem 1,3-fachen und dem 1,8-fachen des Innendurchmessers des Rohrauslasses (29) liegt.



auslasses (29) liegt.

5. Vorrichtung zur Vakuumdestillation nach irgendeinem der Ansprüche 1 bis 4, wobei bei drei Viertel der Länge der Verbindungsleitung (3) ihr Innendurchmesser zwischen dem 1,7-fachen und dem 4,5-fachen des Innendurchmessers des Rohrauslasses (29) liegt.
6. Vorrichtung zur Vakuumdestillation nach irgendeinem der Ansprüche 1 bis 5, weiter umfassend eine Überführungsleitung (40), die sich zwischen dem Auslassende (34) der Verbindungsleitung (3) und dem Säuleneinlaß (6) erstreckt, wobei die Überführungsleitung (40) einen Innendurchmesser hat, der zwischen dem 0,7-fachen und 5,7-fachen des Innendurchmessers des Auslassendes (34) der Verbindungsleitung (3) liegt.

Revendications

1. Dispositif de distillation sous vide comprenant une colonne de distillation sous vide (1) ayant une entrée de colonne (6), une sortie inférieure (8) et une sortie supérieure (10), un four (2) équipé d'un tube échangeur de chaleur (27) ayant une entrée de tube (28) et une sortie de tube (29) et un conduit, de raccordement (3) équipé d'une extrémité d'entrée (33) raccordé à la sortie de tube (25) et d'une extrémité de sortie (34) qui est en communication de fluide avec l'entrée de colonne (6), caractérisé en ce que le diamètre intérieur du tube échangeur de chaleur (27) augmente tout au long de la longueur du tube échangeur de chaleur (27) jusqu'à entre 2,4 et 3 fois le diamètre intérieur de l'entrée de tube (28), en ce que à 95% de la longueur du tube échangeur de chaleur (27) son diamètre intérieur est entre 1,0 et 1,6 fois le diamètre intérieur de l'entrée de tube (28) et en ce que le diamètre intérieur du conduit de raccordement (3) augmente graduellement tout au long de la longueur du conduit de raccordement (3) jusqu'à entre 2,5 et 5,4 fois le diamètre intérieur de la sortie de tube (29).
2. Dispositif de distillation sous vide selon la revendication 1, dans lequel à 98% de la longueur du tube échangeur de chaleur (27) son diamètre intérieur est entre 1,7 et 2,3 fois le diamètre intérieur de l'entrée de tube (28).
3. Dispositif de distillation sous vide selon les revendications 1 ou 2, dans lequel à un quart de la longueur du conduit de raccordement (3) son diamètre intérieur est entre 1,0 et 1,8 fois le diamètre intérieur de la sortie de tube (29).

4. Dispositif de distillation sous vide selon l'une quelconque des revendications 1 à 3, dans lequel à la moitié de la longueur du conduit de raccordement (3) son diamètre intérieur est entre 1,3 et 1,8 fois le diamètre intérieur de la sortie de tube (29).
5. Dispositif de distillation sous vide selon l'une quelconque des revendications 1 à 4, dans lequel aux trois quarts de la longueur du conduit de raccordement (3) son diamètre intérieur est entre 1,7 et 4,5 fois le diamètre intérieur de la sortie de tube (29).
6. Dispositif de distillation sous vide selon l'une quelconque des revendications 1 à 5, comprenant, de plus, un conduit de transfert (40) s'étendant entre l'extrémité de sortie (34) du conduit de raccordement (3) et l'entrée de colonne (6), lequel conduit de transfert (40) a un diamètre intérieur entre 0,7 et 5,7 fois le diamètre intérieur de l'extrémité de sortie (34) du conduit de raccordement (3).